DOCUMENT RESUME

ED 133 419 CE 007 524

AUTHOR Crowder, John; Carpenter, Bruce
TITLE Fuels and Lubricants. An Instructional Unit for High School Teachers of Vocational Agriculture.
INSTITUTION Curriculum Development Center of Kentucky, Lexington.
PUB DATE 74
NOTE 48p.; For related documents see CE 007 522-524

EDRS PRICE MF-$0.83 HC-$2.06 Plus Postage.
DESCRIPTORS *Agricultural Engineering; *Agricultural Machinery; Behavioral Objectives; Curriculum Guides; *Fuels; *Lubricants; Secondary Education; Teaching Guides; Units of Study (Subject Fields); *Vocational Agriculture; Vocational Education

ABSTRACT

Designed as a 2-week course of study in the agricultural mechanics curriculum to be taught at the junior and senior high school level, unit on fuels and lubricants is divided into eight major performance objectives. Each objective is subdivided into the areas of content, suggested teaching and learning activities, resources, and evaluation. Topics for the eight sections are (1) importance of fuels and lubricants, (2) properties of fuels, (3) selecting fuels, (4) describing oils, (5) selecting oils, (6) selecting greases, (7) storing fuels and lubricants, and (8) changing oil and oil filter and greasing tractor. (NJ)

****
* Documents acquired by ERIC include many informal unpublished *
* materials not available from other sources. ERIC makes every effort *
* to obtain the best copy available. Nevertheless, items of marg. *
* reproducibility are often encountered and this affects the quality *
* of the microfiche and hardcopy reproductions ERIC makes available *
* via the ERIC Document Reproduction Service (EDRS). EDRS is not *
* responsible for the quality of the original document. Reproductions *
* supplied by EDRS are the best that can be made from the original. *
****

ED133419

Fuels and Lubricants

An Instructional Unit for High School
Teachers of Vocational Agriculture

Developed by:

John Crowder
Teacher of Vocational Agriculture
Jessamine County High School
Nicholasville, Kentucky

Prepared by:

Bruce Carpenter
Curriculum Specialist
Curriculum Development Center

VT-103-429

1974

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
NATIONAL INSTITUTE OF EDUCATION
THIS DOCUMENT HAS BEEN REPRODUCED EXACTLY AS RECEIVED FROM THE PERSON OR ORGANIZATION ORIGINATING IT. POINTS OF VIEW OR OPINIONS STATED DO NOT NECESSARILY REPRESENT OFFICIAL NATIONAL INSTITUTE OF EDUCATION POSITION OR POLICY

CE 007 524

ACKNOWLEDGMENT

We are grateful to Mr. Jay Bucy for his excellent assistance in analyzing the technical content of the unit. Also, special thanks is extended to Mrs. Pat Schrader for editing the material.

CONTENTS

Page

List of Objectives iv

Suggestions for Unit Use v

Lessons

I. Importance of Fuels and Lubricants 1

II. Properties of Fuels 5

III. Selecting Fuels 9

IV. Describing Oils 17

V. Selecting Oils 21

VI. Selecting Greases 29

VII. Storing Fuels and Lubricants 33

VIII. Changing Oil and Oil Filter and Greasing Tractor 37

Reference List 41

UNIT: FUELS AND LUBRICANTS

Major Objective:

Upon completion of this unit, the student will have developed the ability to properly use fuels and lubricants for tractors and agricultural equipment.

Performance Objectives: The student will

I. Describe the importance of proper fuels and lubricants to tractor and equipment use.

II. Describe the properties of fuels as they relate to combustion and use.

III. Select fuels for different types of engines.

IV. Describe the basic characteristics of oils.

V. Select oils for tractors and agricultural equipment.

VI. Select greases for lubrication.

VII. Identify the proper practices for fuel and lubricant storage.

VIII. Change the oil and oil filter and grease a tractor.

UNIT: FUELS AND LUBRICANTS

Suggested Teaching Time:

The teacher should allow approximately two weeks to cover this unit on fuels and lubricants and can plan to use it at any time during the school year. It can be taught primarily in the classroom, but some time should be spent in the mechanics laboratory.

Place of the Unit in the Course of Study:

This unit should be taught during the freshman year and coordinated with the unit on tractor maintenance and safety, or it could be used as a part of the full time agricultural mechanics program taught during the junior and/or senior years. Regardless of when it is taught, the unit should aid the student in developing the ability to properly use and store fuels and lubricants.

Suggestions for Introducing the Unit:

In introducing the unit, the importance of proper care of farm tractors and machinery should be stressed, and the student should come to understand that the proper use of fuels and lubricants is a basic method of prolonging the useable life of farm tractors and machinery.

Create interest by taking the students on a field trip to a local implement dealer. Show the students examples of torn-down tractors and equipment that had to be prematurely overhauled because of poor fuel and lubrication practices. Compare with torn-down tractors

that have performed for a longer working life due to proper fuel and lubrication practices. Discuss with the students which tractor has been most economical and will be the easiest to recondition.

After interest has been created, involve the students in discussing the different steps to follow in proper storage of fuels and lubricants. Differences of opinions which may arise concerning these steps should stimulate even further interest.

I. The student will describe the importance of proper fuels and lubricants to tractor and equipment use.

A. Content

1. Characteristics of modern tractors and equipment that require the use of proper, high quality fuels and lubricants

a. Modern tractors and equipment are more efficient and sophisticated than models of previous years.

(1) Modern engines are designed to last longer and run more efficiently.

(a) Compression ratios are higher.
(b) Modern engines run at higher RPM's.
(c) Modern engines create more heat.
(d) Modern engines are designed more precisely and are more rugged in construction.
(e) Lubrication systems have been improved.
(f) Fuel efficiency (horsepower hours-per-gal) has been increased.

(2) Modern tractors and equipment have a number of advanced features that older models did not have which create a need for more comprehensive maintenance and lubrication schedules. Examples:

(a) Sophisticated hydraulic systems
(b) Hydrostatic or automatic transmissions
(c) Power steering
(d) Power brakes
(e) Hydraulic clutches
(f) Advanced PTO systems
(g) Turbocharged engines
(h) Differential locks
(i) Multiple range transmissions
(j) Remote hydraulic cylinders and outlets

b. Modern tractors and equipment represent a much larger investment of capital today than in the past.

(1) Retail prices of tractors and equipment have risen drastically during the last two decades.

(2) Tractor and machinery parts have also increased tremendously in price.

(3) The cost of "mechanical work" has increased.

2. Characteristics of modern fuels and lubricants that make them suitable for use in modern tractors and equipment

   a. Over-all quality of fuels and lubricants has increased somewhat during recent years.

   b. Fuels and especially lubricants have become more specialized.

   c. Oil companies have standardized their classifications of fuels and lubricants to a great extent.

   d. Oil companies are doing a better job of designating products and their uses.

3. Advantages of the use of proper fuels and lubricants in tractors and equipment

   a. Power, efficiency, and usefulness (long-life) are increased substantially.

   b. Lower operating cost is realized.

   c. Less down-time for repairs and overhauls is needed.

   d. Greater returns from capital invested.

   e. Pride of ownership is increased.

   f. Well lubricated tractors and equipment are safer to operate.

4. Results from the use of improper fuels

   a. Starting is poor and fuel burns too rapidly.

   b. Engine knock results in damage to the following:

      (1) Pistons
      (2) Rings
      (3) Valves
      (4) Injectors, etc.

   c. There is a vapor lock.

   d. There is decreased fuel efficiency.

e. Dirt and moisture in engine results in the following:

(1) Damage to fuel injection system
(2) Damage to carburetion system
(3) Severe wear on engine parts

5. Results from the use of improper lubricants

a. Starting is poor.

b. Oil contamination results in sludge formation on engine parts.

c. There is oil blow-by (leakage).

d. Excess heat builds up on bearings, rods, etc.

e. Shorter life is due to improper lubrication.

f. There is loss of power due to increased heat and friction.

B. Suggested Teaching-Learning Activities

1. Involve the students in developing a list of parts of a tractor engine that might be damaged by the use of inferior fuels and lubricants.

2. Have the students observe in the shop a tractor which has engine knock as a result of using improper fuel. Compare the sound of the engine to a similar engine without knock.

3. Tear down an engine that has been subjected to use of improper fuels and/or lubricants. Have students observe sludge, carbon, dirt, rust, corrosion, and damaged parts of the engine.

4. Collect from local machinery dealers junked parts from old engines (valves, pistons, crankshaft, heads, etc.) that show evidence of the use of improper fuels and lubricants. Have students ovserve parts and ask questions such as, "What may have caused such damage?"

5. Have a local machinery dealer discuss with the class the use of proper fuels and lubricants.

6. Have students obtain prices of certain tractors and/or equipment from the local dealer. Involve students in a discussion concerning the high price of equipment and the need for proper use of fuel and lubricants.

7. Have students obtain prices of certain repair jobs (ring jobs, valve jobs, complete overhauls, etc.) from local dealers to make them aware of the need for use of proper fuels and lubricants.

8. Involve students in a discussion of the correct and incorrect uses of fuels and lubricants which they have encountered on the farm.

9. Have the students develop an individual list of tractors, trucks, etc. on the home farm. Have them include the kind and type of fuels and lubricants being used in those tractors, trucks, etc.

C. Resources

1. Books:

Fundamentals of Service - Fuels, Lubricants, and Coolants, pp. 1, 27-29

Tractor Fuels and Lubricants - Selecting and Storing, pp. 3-5, 29-30

2. Resource person:

Local machinery dealer

D. Evaluation

Involve the students in discussing orally or in writing the importance of fuels and lubricants to proper tractor and equipment operation. Evaluate the students based on the number of reasons given in the discussion for the importance of using proper fuels and lubricants.

II. The student will describe the properties of fuels as they relate to combustion.

A. Content

1. Properties of tractor fuels as they relate to combustion and use

a. Properties of gasoline

(1) Somewhat light fuel (approx. 6.1 lbs. per gal.)

(2) Highly volatile (will change to a gaseous form and mix with air readily)

(3) Evaporates readily

(4) Will not self-ignite and burn smoothly within a cylinder, thus it cannot be compressed as highly as diesel fuel

(5) High energy fuel

b. Properties of diesel fuel

(1) Heavy fuel (approx. 7 lbs. per gal.)

(2) Not very volatile

(3) Does not readily evaporate

(4) Can be highly compressed within a cylinder and will self-ignite and burn smoothly

(5) Contains more energy per gallon (BTU's) than any other fuel used in tractors today

2. Characteristics of tractor engines that determine type of fuel used

a. Mixing of fuel and air

(1) Gasoline engine has carburetor which mixes gasoline and air

(a) The mixture enters the cylinder before the compression stroke occurs.
(b) The mixture enters the cylinder already mixed and ready to ignite.

(2) Diesel engine has no carburetor and fuel is not mixed with air until after entering the cylinder

(a) Air enters the cylinder before and during the compression stroke.
(b) After the air is compressed, diesel fuel is injected into the cylinder from an injector pump.

b. Compression of the fuel mixture

(1) Compression ratio and its meaning

(a) Compression ratio is the relationship between the total volume inside the engine cylinder when the piston is at bottom dead center compared to the volume inside the cylinder when the piston is at top dead center.
(b) Compression ratio is expressed in numbers such as 7 to 1 or 16 to 1.

(2) Compression in gasoline tractor engines

(a) The fuel mixture in a gasoline tractor engine is compressed to approximately a 7.5 to 1 ratio.
(b) Compression ratios in tractor engines that use regular gasoline may vary from 7 to 1 to as high as 8.5 to 1.

(3) Compression in diesel tractor engines

(a) The air in a diesel engine is compressed to a very high point before the diesel fuel is injected into the cylinder.
(b) The typical farm tractor diesel engine has a compression ratio of approximately 16 to 1.

c. Ignition of the fuel mixture

(1) Gasoline-air mixture in a gasoline engine ignited by a spark from a spark plug at or near the end of the compression stroke

(2) Diesel fuel-air mixture in a diesel engine ignited by the heat of compression

Note: Air is compressed to such a high temperature (1200-1500 degrees F) that the diesel fuel, upon entering the cylinder, ignites spontaneously.

3. Relationship of fuel mixture to engine combustion

a. The gasoline tractor engine must have a fuel mixture which, after relatively high compression, can be spark-ignited and will burn smoothly to produce an even power stroke.

b. The diesel tractor engine must have a fuel that can be injected into an already compressed cylinder and one that will ignite spontaneously and provide a smooth, even power stroke.

B. Suggested Teaching-Learning Activities

1. Provide samples of gasoline and diesel fuel for the students to examine. Have them note the differences in weight, volatility, evaporation rate, and lubricating value. (Use caution in handling fuels.)

2. On the chalkboard draw a schematic diagram of a diesel piston with a compression ratio of 16 to 1 and compare to a piston in a gasoline engine with a compression ratio of 7 to 1. Use the diagram to explain the role of compression in the selection of fuels.

3. Involve the students in finding the compression ratios of several different gasoline and diesel engines.

4. Involve a local mechanic in discussing with the class the differences in the gasoline and diesel engines.

5. Involve a local mechanic in discussing with the class the differences in the gasoline and diesel engines, giving particular emphasis to these differences as they relate to properties of fuels.

C. Resources

1. Books

Fundamentals of Service - Fuels, Lubricants, and Coolants, pp. 1-3

Tractor Fuels and Lubricants - Selecting and Storing, pp. 5-9

2. Resource person

Local mechanic

D. Evaluation

Have the students list the properties of fuels which relate to combustion. Evaluate the students based on the number of properties listed.

III. The student will select fuels for different types of engines.

A. Content

1. Factors to consider in selecting fuels for gasoline farm tractors

a. Proper octane rating

(1) Octane rating of a fuel is a measure of its anti-knock quality

(a) Fuel knock (detonation, ping, spark knock) can be caused in gasoline engines when a fuel does not have an adequate anti-knock rating.

-- Fuel knock is a result of the fuel-air mixture burning unevenly or self-igniting in the cylinder.
-- Fuel knock can cause damage to valves, pistons, rings, bearings, plugs, gaskets, and other parts of an engine if allowed to continue.
-- Fuel knock causes a loss of power and fuel efficiency.

(2) Relation of octane ratings to tractor use

(a) Raising the octane ratings (anti-knock qualities) of a fuel allows it to be compressed tighter and still ignite smoothly within the cylinder.

(b) The octane rating of regular-grade gasoline has increased gradually during the last few years.

-- Higher octane ratings have led to the development of higher compression ratios in tractor engines to take advantage of increased compression (better fuel efficiency).

(c) Most gasoline farm tractors and engines are designed to run on regular gasoline.

-- There is usually no advantage in using a premium grade gasoline in a farm tractor.

Note: Refer to Table below for data concerning compression ratios and octane ratings.

COMPRESSION RATIOS AND OCTANE RATINGS
USED WITH PRESENT-DAY SPARK-IGNITION FUELS*

Fuel	Engine Compression Ratio (Approx.)	Octane No. (Approx.)
Gasoline (Low grade)	5.0- 7.0 to 1	70-85
Gasoline (Regular)	7.0- 8.5 to 1	88-94
Gasoline (Premium)**	9.0-10.0 to 1	about 100
Gasoline (Super Premium)**	9.5-10.5 to 1	over 100
**Not normally used in tractors		

b. Ease of starting characteristics

(1) The starting characteristics of a fuel are affected most by its volatility (ability to vaporize and mix with air).

(2) Winter gasolines are highly volatile at low temperatures to aid in starting.

c. Use of fuel additives

(1) Some of the major gasoline additives used in today's gasolines and their functions:

(a) Anti-knocks

-- Tetra-ethyl lead to increase gasoline octane number and prevent fuel knock.
-- Scavengers (included as part of anti-knock compound) which convert non-volatile combustion products into a form that can be vaporized from hot engine surfaces.

* Courtesy of "Fuels and Lubricants Selecting and Storing," American Association for Vocational Instructional Materials

-- Certain hydrocarbon fractions of high octane increase the octane in nonleaded fuels.

(b) Deposit modifier additives to eliminate surface ignition (pre-ignition) and spark plug fouling

(c) Antioxidants to prevent gasoline from oxidizing and forming gum deposits which are harmful to engine parts

(d) Anti-rust agents to prevent the formation of corrosion and rust which are harmful to the fuel system of gasoline engines

(e) Anti-icing agents to prevent fuel line and carburetor freeze-up due to moisture in the fuel

-- Freezing point depressants such as alcohol and glycols lower the freezing point of the water vapor in the air.
-- Surface active agents such as ammonium salts of phosphates provide a coating on the metal surfaces of the carburetor to prevent ice build-up.

(f) Carburetor detergents such as amides and alkyl amine phosphates which coat the surface of the carburetor and prevent contaminates from exhaust and crankcase fumes from accumulating

(g) Dyes which are used to indicate the presence of anti-knocks, promote sales appeal, and identify various makes and grades of gasoline

d. Freedom from dirt and moisture

(1) Dirt and moisture usually enter gasoline as a result of improper handling and storage.

(2) Refiners, distributors, and dealers are usually well equipped and careful in handling and storing fuel to avoid dirt and moisture.

2. Actual selection of gasoline for farm gasoline engines

a. A good quality regular grade gasoline should be selected for use in farm gasoline engines.

b. An octane rating of 90-94 should be adequate for all farm gasoline engines.

(1) Consult with operator's manual or oil dealer before using non-leaded gasoline in farm engines.

(2) Starting characteristics (summer or winter blend) cleanliness, and additives are built-in or included in all good gasolines and not of direct concern to the buyer.

3. Factors to consider in selecting diesel fuel for farm diesel tractors

a. Proper cetane rating

(1) The cetane number in a diesel fuel is a measure of its ability to self-ignite.

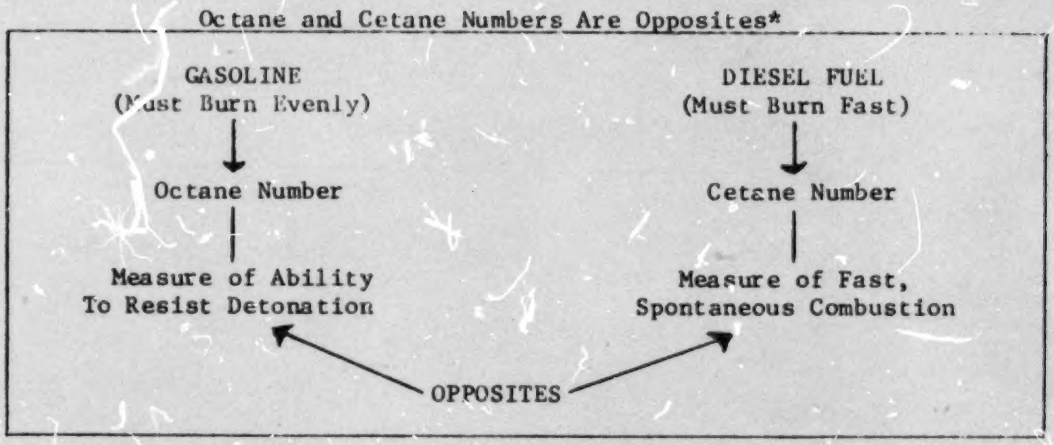
(a) In the diesel engine, air is compressed in the cylinder to a high temperature (as high as 1200 degrees F) and high pressure (as high as 900 psi), and then the fuel is injected into the cylinder and self-ignites with the air to give the power stroke.

(b) The diesel fuel must self-ignite quickly in order for the diesel engine to run smoothly and without knock.

-- As the cetane number rating increases, the self-igniting qualities and starting characteristics of a fuel increases.

(c) Cetane rating for diesel fuel and octane rating for gasoline are opposites, and should not be confused.

-- Since the diesel cycle requires a fuel that must self-ignite, fuel knock (detonation) is prevented by the ability of the fuel to self-ignite quickly.
-- In a spark-ignition engine, self-ignition is not wanted and every effort is made to prevent it. Self-ignition in a gasoline engine causes fuel knock (detonation).
-- The differences between octane numbers and cetane numbers is illustrated in the chart on the following page.



(2) Relation of cetane ratings to tractor use

(a) An adequate cetane number is needed most when starting a cold diesel engine.

--Results from the use of a fuel with too low a cetane number may be hard starts, slow warm-ups, and fuel deposit build-ups which are harmful to the engine.
--Using a fuel that is too high in cetane number can result in incomplete combustion and exhaust smoke.

(b) Most farm tractor diesel engines are designed to run on fuels with cetane ratings that vary from 40 to 60, the average approximately 50.

--The owner's manual should always be consulted to find out the cetane requirements for a certain tractor.
--The minimum cetane rating for No. 1 and No. 2 diesel fuels is 40.

b. Freedom from contaminants

(1) Diesel fuel must be cleaner and have fewer contaminants than any other fuel used in farm tractors.

* Courtesy, John Deere Service Publications

(a) The fuel system of the diesel engine is so precise and expensive that the fuel must be absolutely clean and free of contaminants.

(b) The spray opening of a typical diesel fuel injector is .001 inch in diameter.

(c) The high cost of pumps, injectors, and/or diesel mechanics labor demand that clean fuel be used.

(2) The most important contaminants in diesel fuel from an operator's standpoint include the following:

(a) Sulfur which can combine with water to form acids that cause rapid wear and the formation of deposits in the cylinder and on the rings and valves

(b) Water which can cause rust, freeze-up, and interfere with proper injector lubrication

(c) Dirt which can clog the tiny openings in pumps and injectors and cause complete failure

c. Grades of fuel

(1) The following diesel fuels are used almost exclusively in farm tractors and have been refined to meet or exceed certain specifications as defined by the American Society for testing materials.

(a) Number 1 diesel fuel (no. 1-D) is commonly recommended for cold weather use because it remains fluid and provides easier starting. It is suitable for use in high-speed engines and in service involving frequent and relatively wide variations in loads and speeds.

-- Characteristics of No. 1-D

- Minimum cetane number rating of 40
- Maximum sulfur content by weight of 0.5%
- Usually costs more than No. 2-D

(b) Number 2 diesel fuel (No. 2-D) is heavier than No. 1-D and supplies more energy per gallon, making it more desirable for heavy work loads. It is suitable for use in high-speed engines in service involving relatively high loads and uniform speeds.

-- Characteristics of No. 2-D

- Minimum cetane number rating of 40
- Maximum sulfur content by weight of 1%
- Usually costs less than No. 1-D
- Commonly recommended for summer use in farm tractors
- Has higher viscosity which provides better lubrication to injectors than No. 1-D

Note: In some areas, a dealer may stock only one fuel (due to demand) that will meet the qualifications for both diesel fuel and furnace fuel use. The specifications for both fuels may be so broad they overlap. However, if the dealer stocks separate fuels for diesel use and heating purposes, the diesel fuel only should be used, as the furnace fuel may contain too many impurities for diesel engine use.

4. Actual selection of diesel fuel for farm diesel engines

   (1) No. 2 diesel fuel with a cetane rating of 45 to 50 should be adequate for practically all farm diesel engines.

   (2) Cleanliness and additives are included in a good diesel fuel and are not of direct concern to the buyer.

B. Suggested Teaching-Learning Activities

1. Involve a resource person such as a local mechanic in discussing with the class the advantages of selecting proper fuels. Have him also bring out the disadvantages and results from using improper fuels in tractor engines.

2. Secure and display for the students a number of damaged engine parts, such as burned or broken pistons, valves, and piston rings that resulted from gasoline fuel knock.

3. Secure and display for the students a number of diesel fuel system parts, such as injector pumps, lines, and nozzles that have rusted, clogged, or otherwise damaged due to the use of improper fuels. Point out to the students the tiny openings and clearances and how easily they might be damaged or clogged when using dirty or improper fuel.

4. Involve a resource person such as a local fuel distributor in discussing with the class the fuels that he stocks and a description of his fuels, such as their octane and cetane ratings.

5. Have the students determine the proper fuels for tractors by consulting operator's manuals. This will increase their awareness that tractor manufacturers do specify certain fuel requirements for their tractors.

C. Resources

1. Books

Fundamentals of Service - Fuels, Lubricants, and Coolants, pp. 4-9, 10-15

Tractor Fuels and Lubricants - Selecting and Storing, pp. 10-14, 16-19

2. Bulletins and Circulars

"Gasoline - Questions and Answers"

"Diesel Fuel - Questions and Answers"

3. Resource People

Local tractor mechanic

Local fuel distributor

4. Films

"Selecting Fuels and Lubricants," American Association for Vocational Instructional Materials, Engineering Center, Athens, Georgia

D. Evaluation

Develop hypothetical situations pertaining to different tractor working conditions. Involve the students in selecting fuels for those situations and listing characteristics of the fuels which they select. Evaluate the students based on the correctness of the fuels selected and on the number of characteristics listed for their choice of fuel.

IV. The student will describe the basic characteristics of oil.

A. Content

1. Functions of oil

a. Reduces friction and wear between moving parts

b. Acts as a coolant to moving parts

c. Acts as a seal against escaping gases

d. Keeps the parts clean

e. Provides protection against rust and corrosion

2. Properties of oil

a. Viscosity - measurement of an oil's resistance to flow

(1) Expressed by SAE (Society of Automotive Engineers) numbers - 10W, 20W, 20, 30, 40, 50, etc.
Note: The letter "W" designates winter use and the number refers to viscosity.

(2) Results of improper viscosity

(a) Viscosity too low (oil too thin) allows leakage past seals and fittings resulting in oil breaking down under high operating temperatures.

(b) Viscosity too high (oil too thick) results in hard starts, sluggish operation, and poor lubrication.

b. Viscosity index

(1) Measure of an oil's change in thickness with respect to change in temperature

(a) When an oil becomes thick at low temperatures and very thick at high temperatures, it has a low viscosity index.

(b) When an oil remains relatively the same at varying temperatures, it has a high viscosity index.

(2) Change in viscosity prevented by adding viscosity index improvers to oils

Note: The use of viscosity index improvers has initiated such terms as "multi-grade" and "multi-purpose" and "all-weather" in oils.

c. Oil additives (some of the following additives are found in nearly all oils today, but it is unlikely that all of the following additives would be found in any one oil.)

(1) Anti-corrosion additive helps prevent corrosive acids from forming and protects metal surfaces from corrosive attack.

(2) Oxidation inhibitor additive helps keep oil from oxidizing (forming rust) at high temperatures and prevents acid, varnish, and sludge build-up.

(3) Anti-rust additive prevents rusting of metal parts.

(4) Viscosity index improver prevents change in viscosity thus giving oil the beneficial properties of both light and heavy oils.

(5) Pour-point depressant additive prevents wax crystals from congealing and forming lumps that would interfere with oil flow.

(6) Extreme pressure additive assures lubrication where extreme pressures between close tolerance and metal-to-metal surfaces are encountered.

(7) Detergent dispersant additive helps keep metal surfaces clean and prevents deposit formation.

(8) Foam inhibitor additive helps prevent air bubbles which would cause oil to foam and restrict lubrication.

B. Suggested Teaching-Learning Activities

1. Take a field trip to a local implement dealer for the students to observe repairs being made on tractor engines, transmissions, hydraulic systems, etc., repairs that were made necessary because of inadequate lubrication.

2. Show filmstrip on "Fuels and Lubricants" available from American Association of Vocational Instructional Materials.

3. Assemble an assortment of used tractor engine, transmission, and/or hydraulic system parts that show evidence of rust and corrosion damage, damage due to dirt and grit contamination, worn seals and packings, etc. Involve the students in examining the parts for wear and then discuss the cause of the wear.

4. Demonstrate to students the foaming action of oils by puttng a low grade oil in a glass jar and shaking it vigorously until it foams. Repeat with high grade oil and observe the difference.

5. Have students pour out different grades of oil to demonstrate to them the difference in viscosity. Let them feel the oil between their fingers.

6. Assemble an assortment of empty oil cans and let students observe SAE viscosity numbers to be aware of them.

7. Involve as a resource person a local oil distributor. Have him explain to students the different lubricants that he stocks and the characteristics of each.

C. Resources

1. Books

Fundamentals of Service - Fuels, Lubricants, and Coolants, pp. 27-32, 37-44, 46-53

Tractor Fuels and Lubricants - Selecting and Storing, pp. 29-38, 41-43, 45-47

Lubricants and Hydraulic Fluids - What They Do, and Why

Lubrication Farm Manual - Farm and Home Management Series

2. Resource people

Local implement dealer

Local distributor or dealer of lubricants

3. Filmstrip

"Tractor Fuels and Lubricants," American Association for Vocational Instructional Materials, Engineering Center Athens, Georgia

D. Evaluation

Have students list and describe the functions and properties of oils. Evaluate the students based on the number of correct functions listed and adequately described.

V. The student will select oils for tractors and agricultural equipment.

A. Content

1. Types of oils

a. Crankcase oil

(1) Used for engine lubrication

(2) Requirements of crankcase oil

(a) Retain fluid enough for engine to start easily at all normal operating temperatures

(b) Retain enough body to reduce friction and wear between surfaces

(c) Remove heat caused by friction

(d) Provide a seal against escaping gases in the cylinders

(e) Keep the engine clean

-- Keep carbon, soot, and sludge-forming materials in suspension so they will be removed when the oil is drained

(f) Provide protection against rusting and attack by acids

(g) Prevent ring sticking

(h) Resist foaming

(i) Resist breakdown after prolonged use

b. Gear Oil

(1) Used in transmissions, differentials, and power take-off units

(2) Requirements of gear oil

(a) Assure easy gear shifting in cold weather in manual transmissions

(b) Assure quick, free, smooth operation of hydraulically operated transmissions

(c) Keep moving metallic surfaces separated

(d) Reduce friction and wear

(e) Prevent scoring and welding of highly stressed parts

(f) Act as a coolant

(g) Resist oxidation, foam, corrosion, and channeling

(h) Contain extreme pressure properties

(i) Protect seals and gaskets

c. Hydraulic oil

(1) Used in implement-control systems, steering mechanisms, brakes, transmissions, torque converters, differential locks, pto drives, and hydraulic motors

(2) Types of hydraulic oil

(a) Crankcase oil
(b) Gear oil
(c) Special oils from tractor manufacturers
(d) Automatic transmission fluids

(3) Requirements of hydraulic oils:

(a) Be free from dirt, water, and other contaminants

(b) Possess proper viscosity

(c) Resist oxidation, foaming, and air collecting in the system

(d) Protect against rusting and corrosion

(e) Protect oil seals

(f) Protect against rapid wear of metal parts

(g) Transmit power

2. Basis for selection of oils

a. Viscosity

(1) Viscosity in oil expressed by a number(s)

(a) Single viscosity oils have one number, such as Society of Automatic Engineers (SAE) 20, SAE 30, SAE 10W.

(b) The use of the letter "W" following the number designates the oil as a winter oil.

(c) Multi-grade oils have two numbers, such as SAE 10W-30.

(d) In a multi-grade oil, the lowest number applies to low-temperature operation, and the high number to high-temperature operation.

(e) One multi-grade oil can meet the viscosity requirements for as many as four or five single-grade oils. (See example below)

Single-grade oils	Multi-grade oils
SAE 10W	
SAE 20W	
	SAE 10W-30
SAE 20	
SAE 30	

(f) Viscosity numbers of common crankcase oils (Refer to table below)

Single Viscosity Oils	Multi-Viscosity Oils
SAE 5W	SAE 5W-20
SAE 10W	SAE 10W-30
SAE 20W	SAE 10W-40
SAE 20	SAE 20W-40
SAE 30	
SAE 40	
SAE 50	

(g) Viscosity numbers of common gear oils (Refer to table below)

Note: Since gear oils are completely different products from crankcase oils, the society of Automotive Engineers has established a different set of viscosity numbers to use with gear oils.

Viscosity Numbers of Gear Oils

SAE 75	SAE 75-80
SAE 80	SAE 80-90
SAE 90	
SAE 140	
SAE 250	

(2) Determining viscosity (grade) of oil to use

(a) Factors that determine viscosity of oil to use

-- Operating temperatures
-- Type of engine, transmission etc.
-- Fuel to be used
-- Type of load or work to be done

(b) The operator's manual always gives the recommended viscosity numbers for crankcase and gear oils and its recommendations should be followed.

(c) Multi-viscosity oils are intended for use during seasons in which both extreme cold and warm temperatures occur.

b. Oil types

(1) The American Petroleum Institute (API) has developed a method of classifying oils by types (quality) in order to match oil quality with the following:

(a) The fuel being used
(b) The severity of operating conditions

(2) Each oil company classified its oils in relation to the API specifications.

(3) API classifications have been revised over the years (1971 - latest revision) to keep abreast with the development of better oils and more critical oil demands.

(4) Although API classifications are most commonly used to classify oils as to type, certain other classifications have been used in the past and are presently used by oil companies to rate their products.

(a) Military specifications
(b) Caterpillar Engine Company specifications
(c) Sequence test by auto manufacturers

(5) Refer to the chart below for the API identification for nine different types of service for crankcase oils.

New API Engine Service Classifications	Previous API Engine Service Classifications
Service Station Engine Services	
SA	ML
SB	MM
SC	MS (1964)
SD	MS (1968)
SE	None
Commercial and Fleet Engine Services	
CA	DG
CB	DM
CC	DM
CD	DS

(6) API classifications for common gear oils include the following:

(a) API GL-1
(b) API GL-2
(c) API GL-3
(d) API GL-4
(e) API GL-5
(f) API GL-6

(7) Selection of hydraulic oils are not based on special API classifications.

(a) The hydraulic oil should match the hydraulic system.

(b) Use the type of oil that the tractor manufacturer recommends.

3. Actual selection of oils

a. Selection of crankcase oil

(1) Select viscosity number based on prevailing work temperature(s) and manufacturers recommendations.

(a) In cold weather, use a light oil such as SAE 5W or SAE 10W.

(b) In warm weather, use a heavier oil such as SAE 30 or SAE 40.

(c) A multi-viscosity oil such as SAE 10W-30 is usually desirable when temperatures vary a great deal during the year.

(2) Select oil type based on manufacturers' recommendations and prevailing work conditions.

(a) For moderate work conditions use the following:

-- API type SE for gasoline tractors
-- API type CC for diesel tractors

(b) For severe work conditions use the following:

-- API type CC for gasoline tractors
-- API type CD for diesel tractors

b. Selection of gear oil

(1) Select viscosity number based on prevailing work temperature(s) and manufacturers' recommendations.

(a) In cold weather, use a light gear oil such as SAE 80.

(b) In warm weather, use a heavier gear oil such as SAE 90 or SAE 140.

(c) A multi-viscosity gear oil such as SAE 80-90 may be desirable when temperatures vary a great deal during the year.

(2) Select oil type based on manufacturers' recommendations and prevailing work conditions.

(a) For moderate work conditions use API GL-3 or API GL-4.

(b) For severe work conditions use API GL-5 or API GL-6.

c. Selection of hydraulic oils

(1) Select hydraulic oil based strictly on manufacturers recommendations.

(a) If transmission oil is recommended for hydraulic purposes, use a special all-purpose oil produced by the respective tractor manufacturer.

(b) If automatic transmission fluid is recommended for hydraulic purposes, use the recommended types only.

B. Suggested Teaching-Learning Activities

1. Involve as a resource person a local oil distributor. Have him explain to students the different classifications of oils.

2. Assemble an assortment of different types of oil cans. Have students observe specifications and recommendations given on the cans.

3. Provide small quantities of crankcase, gear, and hydraulic oils for students to observe and compare.

4. Have the student find the oil requirements for three or four different tractors. Have the student make a list of crankcase oils, gear oils, and hydraulic oils required.

5. Have students check the oils that are being used on the home farm. Compare the oils being used to those recommended.

C. Resources

1. Books

Fundamentals of Service - Fuels, Lubricants, and Coolants, pp. 28-44, 46-53

Tractor Fuels and Lubricants - Selecting and Storing, pp. 30-47

Lubricants and Hydraulic Fluids - What They Do and Why, pp. 5-8, 14-24

2. Bulletins and Circulars

"Engine Service Classifications and Guide to Crankcase Oil Selection"

"Lubricant Service Designations for Automotive Manual Transmissions and Axles"

3. Resource people

Local distributor or dealer of lubricants

D. Evaluation

Involve the students in selecting different types of oils for different work situations and evaluate them based on the reasons given for different oil selections.

VI. The student will select greases for lubrication.

A. Content

1. Definition of "grease"

a. A grease may be defined as a solid or semi-fluid lubricant of dispersion in a liquid lubricant (usually a petroleum oil).

b. Lubricating grease is usually a blend of lubricating oil and soap with stabilizers and additives.

c. Requirements for a grease

(1) Provide adequate lubrication to all moving parts

(2) Have suitable physical characteristics for the method of application

(3) Act as a seal to prevent entrance of dirt and water

(4) Resist leakage, dripping, or throw-off from lubricated surfaces

(5) Protect against corrosion

(6) Resist change in consistency with mechanical working

(7) Avoid excessive stiffening resulting in undue resistance to motion in cold weather

(8) Be compatable with seals and other materials of construction in the lubricated portion of the mechanism

(9) Tolerate some degree of contamination, such as moisture, without loss of significant characteristics

2. Characteristics of greases

a. Properties

(1) Consistency - the "working" or "penetrating" ability of a grease

(a) Consistency in grease correlates to viscosity in oils.

(b) Consistency in grease is expressed in grades established by the National Lubricating Grease Institute (NLGI).

-- NLGI Grades for Lubricating Greases are as follows:

#000	Lightest
#00	
#0	
#1	
#2	
#3	
#4	
#5	
#6	Heaviest

-- The lower the NLGI grade number, the greater the tendency for leakage from a bearing or fitting.

-- The higher the NLGI grade number, the greater the tendency for frictional losses and poorer lubrication.

-- NLGI #1 or #2 are most commonly recommended for use in farm tractors.

(2) Dropping point (melting point) refers to the temperature at which a grease changes from plastic in structure to liquid in structure.

(3) Apparent viscosity refers to a grease's pumping ability.

(4) Mechanical stability refers to a grease's ability to resist structure break-down under working or kneading action.

(5) Oxidation stability refers to a grease's ability to resist oxidation (forming corrosive acids) at high temperatures.

Note: When a grease is oxidized, it appears stiff and dry and loses its lubricating qualities.

(6) Extreme pressure (EP) properties are properties which increase a grease's ability to maintain a film on metal surfaces under extreme pressure loads.

(7) Anti-rusting properties are properties added to a grease to assure adequate rust protection to metal parts.

b. Grease additives commonly used

(1) Oxidation inhibitors
(2) Corrosion inhibitors
(3) Anti-scuff agents
(4) High temperature stabilizers
(5) Extreme pressure additives
(6) Anti-rust additives

3. Greases from which to select

a. Classes of grease available

(1) Lime soap grease
(2) Soda soap grease
(3) Lithium soap grease
(4) Non-soap grease
(5) Residuum grease

b. Grades of grease available(refer to page 30)

c. Types of grease available

(1) Chassis grease for pressure fittings which is usually lime, soda, or lithium soap

(2) Wheel-bearing grease which is usually lime soap

(3) Water-pump grease which is usually soda or lithium soap

(4) Multi-purpose grease

4. Selection of grease

a. The operator's manual should always be consulted when selecting greases for tractors and farm machinery.

b. If the operator's manual does not give clear and complete recommendations, consult with a good reliable dealer for recommendations concerning use of grease.

c. A good quality multi-purpose grease can now be used for almost all fittings and handpacked bearings.

Note: The use of multi-purpose grease (when possible) eliminates the confusion of selecting different greases for different service applications.

B. Suggested Teaching-Learning Activities

1. Assemble an assortment of used bearings, chassis parts, etc. that show evidence of poor grease lubrication. Involve the students in a discussion of the importance of proper lubrication.

2. Involve as a resource person a local lubricant distributor. Have him explain to students the different greases that he stocks and the characteristics of each.

3. Provide small quantities of several different types and grades of greases for students to examine. Have the students compare the "feel" of each of the greases.

4. Involve the students in finding the grease requirements for several tractors or pieces of farm machinery based on recommendations from operators' manuals.

5. Involve the students in checking the greases that are being used on the home farm to see if the recommended greases are being used.

C. Resources

1. Books

Lubricants and Hydraulic Fluids - What They Do and Why, pp. 25-34

Tractor Fuels and Lubricants - Selecting and Storing, pp. 47-49

Fundamentals of Service - Fuels, Lubricants, and Coolants, pp. 53-54

Lubrication Farm Manual - Farm and Home Management Series, pp. 8-9

2. Resource person

Local distributor or dealer of greases

D. Evaluation

Develop hypothetical situations pertaining to different working conditions for various pieces of equipment. Have the students select greases to be used on the various pieces of equipment and list characteristics of the greases which they select. Evaluate the students based on the correctness of the grease selected and on the number of characteristics listed for their choice.

VII. The student will identify the proper practices for fuel and lubricant storage.

A. Content

1. Factors to consider in storage of tractor fuels

a. Protection of fuel quality (including cleanliness)

b. Safety

c. Convenience

d. Cost

2. Methods of storing fuels

a. Above-ground tanks

(1) Most common type of tank used by farmers

(a) Relatively inexpensive to buy and install
(b) Commonly furnished to a farmer free by a dealer to promote that dealer's sales

(2) Problems resulting from use of above-ground tanks

(a) Evaporation loss of gasoline
(b) Gum deposits in gasoline and diesel fuel
(c) Moisture condensation
(d) Methods of reducing problems

-- Painting tank with white or aluminum paint
-- Providing a shady area for tank
-- Installing a pressure-vacuum relief valve

(3) Installation recommendations

(a) Located at least 40 feet from nearest building
(b) Equipped with self-closing valve for fire protection if tank is gravity fed
(c) Supported firmly
(d) Located 6" off ground
(e) Elevate the outlet end of tank about 4" so dirt and moisture will accumulate in low end of tank and will not be drawn out with fuel.
(f) Equipped with a drain valve so moisture and dirt can be removed periodically
(g) Grounded for lightning and static electricity

b. Under-ground tanks

(1) Most expensive type of tank to purchase and install

(2) Evaporation loss, gum deposits, and condensation are substantially reduced by using this type of tank

(3) Can be located within one foot of a building foundation

(4) Should be coated with an asphalt tar to prevent corrosion

(5) Should be installed in a well drained area or anchored down to prevent flooding or floating out of the ground

(6) Should have provision for a periodic cleaning (a hand pump or man-hole) so water and dirt can be removed

c. Portable tanks or barrels used with pick-up trucks

3. Storing tractor fuels (gasoline and diesel fuel)

a. Safety factors

(1) All fuel tanks must be properly vented to eliminate pressure build-up.

(2) Do not locate tanks in a low area where fuel vapors could accumulate, causing an explosion hazard.

(3) Label all fuel tanks; designate what they are used for.

(a) Red paint is used to designate gasoline.
(b) A black letter "F" can be used to designate diesel fuel.

(4) Never allow smoking in the vicinity of the fuel tanks.

(5) Keep a dry-type fire extinguisher handy.

b. Convenience factors

(1) Locate fuel storage in the vicinity of the tractor and machinery storage area.

(2) If possible, allow about 50 feet on one side of the tank for manuevering tractor and equipment.

c. Quality protection factors

(1) Keep fuel clean.

(a) Drain and clean fuel tanks at least once a year.

(b) Provide a fuel filter between the tank outlet and the delivery hose.

-- Change filter at least once a year

(c) Provide a cover for fuel nozzle when not in use.

(d) Never use same tank for different fuels.

(e) Avoid use of open containers to transfer fuel from tank to tractor.

(f) Avoid fueling tractor from a tank that has just been refilled (especially a diesel.)

-- Allow at least 24 hours for dirt and water to settle to bottom of tank.
-- Never fuel from a tank that has recently been moved or shakened.

(g) Avoid storing diesel fuel in a galvanized tank.

(2) To protect fuel quality by avoiding evaporation, gum deposit, and condensation, keep the fuel supply limited to

(a) A 30-day gasoline supply.

(b) A 90-day diesel fuel supply.

(3) When using a portable tank in pick-up truck, keep tank "extra-clean" and be sure to use a fuel filter at tank outlet.

4. Storing lubricants

a. Protect lubricant quality by eliminating the following:

(1) Dirt

(2) Moisture

(3) Excessive heat and excessive cold

b. Store lubricants inside when possible

(1) Store drums and cans in a dust-free location.

(2) Keep pumps, filler cans, and measuring devices free from dust.

(3) Wipe off top of drum before changing pump

c. If lubricants must be stored outside, practice the following:

(1) Store drums under shelter.

(2) Tighten bungs with a wrench and wooden hammer.

(3) If cover cannot be provided, store drums on their sides on a rock.

(4) If drums must be sorted upright, tilt the drums to enable water to collect away from bungs.

(5) Avoid buying lubricants in large quantities to prevent hot and cold temperatures from damaging their quality.

B. Suggested Teaching-Learning Activities

1. Involve as a resource person a local fuel distributor. Have him lead a discussion concerning proper storage of fuels and lubricants.

2. Discuss with the students the methods used on the home farm for storing fuels and lubricants. List ways home storage can be improved.

C. Resources

1. Books

Farm Tractor Maintenance, pp. 37-45, 54-55

Tractor Fuels and Lubricants - Selecting and Storing, pp. 19-27, 49-51

Fundamentals of Service - Fuels, Lubricants, and Coolants, pp. 16-23, 45

2. Resource person

Local fuel and lubricants distributor

D. Evaluation

Develop a list of proper and improper storage practices for fuels and lubricants. Evaluate the students based on the number of correct practices they can identify.

VIII. The student will change the oil and oil filter and grease a tractor.

A. Content

1. Using oils

a. When to change oil

(1) The oil change recommendations in the operator's manual should always be followed.

(2) Contrary to some people's opinion, oil does wear out.

(3) The "black-oil-time-to-change" rule is not usually correct.

b. Changing and adding crankcase oil

(1) Oil should be warm when drained so as to allow as many contaminants as possible to be flushed from the engine.

(2) Engine should be started and run until normal operating temperature is reached before oil is drained.

(3) When refilling crankcase or adding oil, tractor should be parked on level ground to allow an accurate reading of the dip-stick.

(a) Before checking oil level on dip-stick, shut engine off and allow a few minutes for oil to drain into crankcase.

(b) Use a clean funnel or can spout when refilling.

c. Use of oil filters

(1) Oil filters should always be used as recommended in the operator's manual.

(a) Failure to change oil filters (even with the use of clean oil) will lead to a premature overhaul of the engine.

(b) Adding new oil to an engine with a dirty oil filter is not an economically sound practice.

(2) After a new oil filter has been installed, oil pressure should always be checked to insure that the filter is on tight and the filter is working satisfactorily.

d. Other practices concerning the use of oils

(1) Avoid using cheap oils.

(2) Avoid mixing different weights and brands of oil.

(a) Different brands of oil should not be mixed in the crankcase (even if oils are of same weight and type).

(b) If the operator must change brands of oil, it is a good idea to drain the crankcase completely of brand "A" oil before adding brand "B" oil.

(3) Oil additives are not usually necessary and may be harmful to a tractor engine.

(a) An oil additive may react with the additives already contained in the crankcase oil and prohibit their effectiveness.

(b) If a recommended oil from a reliable company is used, there should be no need for an additive.

2. Using greases

a. Where to grease

(1) All operators' manuals contain a lubrication chart showing parts that are to be greased.

(2) Lubrication chart should be strictly followed.

b. When to grease

(1) Consult and follow recommendations in the operators' manuals for greasing intervals.

(2) Extremely dusty or abrasive working conditions may shorten greasing intervals.

(3) Grease at end of the day when bearings are warm and grease is more workable.

c. Type of grease(s) to use

(1) Under normal conditions, a good multi-purpose grease should be adequate for all farm machinery.

(2) Under certain conditions (such as for front wheel bearings on a loader tractor) the use of a special heavy-duty grease is justified.

d. Application of grease

(1) Keep bearings and fittings clean!

(a) Always wipe off grease fitting with a rag before applying fresh grease.

(b) Wipe off excess grease after application to prevent dust and dirt from collecting around fittings.

(c) Use a cartridge grease gun to avoid dirt contamination when filling.

(2) Apply proper amount of grease.

(a) Applying too much grease can be as harmful as not applying enough.

(b) Bearing grease must have a working area (room to expand when hot) or the bearing seal will be forced to break.

(c) Apply grease slowly and carefully; only a small amount is needed. When the seal begins to balloon, stop greasing.

3. Lubrication records

a. Permanent lubrication records should be kept on all farm machinery showing the following:

(1) Oil changes

(2) Oil filter changes

(3) Grease records

(4) Bearing repairs and replacements

(5) Other repairs related to lubrication

b. The farmer cannot rely on memory alone to keep lubrication records for several implements.

c. Good lubrication practices and records will minimize repair bills and may increase the value of the implement at trade-in time.

B. Suggested Teaching-Learning Activities

1. Involve as a resource person a local tractor and implement dealer or mechanic. Have him lead a discussion concerning how to use oils and greases properly.

2. Have each student change oil, oil filter, and grease a tractor in the school shop. This could follow a demonstration by the teacher. Provide enough tractors so that each student can participate.

C. Resources

1. Books

4-H Tractor Program - Second Year, pp. 13-21, 57-63

Tractor Maintenance - Principles and Procedures.

Fundamentals of Service - Fuels, Lubricants and Coolants.

Lubrication Farm Manual - Farm and Home Management Series.

2. Bulletins and Circulars

"Bearings and Their Lubrication - Engineering Bulletin B-226A"

3. Resource person

Local farm machinery dealer or mechanic

D. Evaluation

Divide students into teams of four and have each team lubricate a tractor (grease, change oil, and remove filter). Evaluate teams based on quality or work done.

REFERENCE LIST

Books:

Farm Tractor Maintenance by Brown and Morrison, The Interstate Printers and Publishers, Inc., Danville, Illinois, 1973.

4-H Tractor Program - Second Year. University of Kentucky, Cooperative Extension Service, Lexington, Kentucky.

Fundamentals of Service - Fuels, Lubricants, and Coolants. John Deere Service Publications, Moline, Illinois, 1970.

Lubrication Farm Manual, Farm and Home Management Series. American Oil Company, Chicago, Illinois, 1969.

Lubricants and Hydraulic Fluids - What They Do and Why. Kendall Refining Company, Bradford, Pennsylvania.

Tractor Fuels and Lubricants - Selecting and Storing. American Association for Vocational Instructional Materials, Engineering Center, Athens, Georgia, 1970.

Tractor Maintenance - Principles and Procedures. American Association for Vocational Instructional Materials, Engineering Center, Athens, Georgia, 1970.

Bulletins and Circulars:

"Bearings and Their Lubrication - Engineering Bulletin B-226A." American Oil Company, Chicago, Illinois, 1962.

"Diesel Fuel - Questions and Answers." American Petroleum Institute, Division of Marketing, Washington, D.C. 20006, 1971.

"Engine Service Classifications and Guide to Crankcase Oil Selections." American Petroleum Institute, Division of Marketing, Washington, D.C. 20006, Publication 1509, 1972.

"Gasoline - Questions and Answers." American Petroleum Institute, Division of Marketing, Washington, D.C. 20006, 1972.

"Lubricant Service Designations for Automotive Manual Transmissions and Axles." American Petroleum Institute, Division of Marketing, Washington, D.C. 20006, Publication 1560, 1972.